Fire Station Pressure Control

A fire station requires a system to control the pressure of the water supply. The pressure must remain constant. The system consists of 3 large pumps, 1 small pump, 1 variable frequency drive (VFD) and a pressure transducer. Please refer to Figure 1 and 2 for the hardware diagrams.

Y0, Y2, Y4 and Y6 control the operation of the pumps and Y1, Y3, Y5 and Y7 control if the pumps are to be powered by the variable frequency drive or by the 3Φ power.

The system will operate in the following manner,

1. Small pump #1 (for nighttime light load operation) will start first. After VFD reaches 50 Hz. wait 15 seconds. If the water pressure has not reached the preset value then stop pump #1 and wait for 3 seconds, then start large pump #2 with the VFD. After VFD reaches 50 Hz., switch the pump's power to the 3Φ power and wait 15 seconds. If the pressure still hasn't achieved the preset, start pump #3 and perform the same operation as pump #2. If it still hasn't reached preset, start pump #4.

2. If the pressure is greater than the preset for 10 seconds than shut off one pump. Continue shutting off pumps every 10 seconds, until the pressure is at the preset or until small pump #1 is the only one operating.

3. If only one large pump runs at a light load and its VFD frequency is < 30 Hz., switch to small pump #1 to conserve electricity.

4. If only one large pump is necessary to achieve preset pressure, then every two hours switch to an alternate pump, such that, all pumps will wear and tear at the same rate.

5. Every 10 to 20 days, a signal shall be initiated to exercise the fire prevention equipment for 10 minutes.

A state diagram will be used to implement this system. There will be 13 states in the diagram, which will be differentiate by,

R5 R4 Y6 Y4 Y2 Y0

Where,

Y0	small pump #1
Y2	large pump #2
Y4	large pump #3
Y6	large pump #4
R4	column indicator
R5	column indicator

Please refer to Figure 3 for the state diagram.

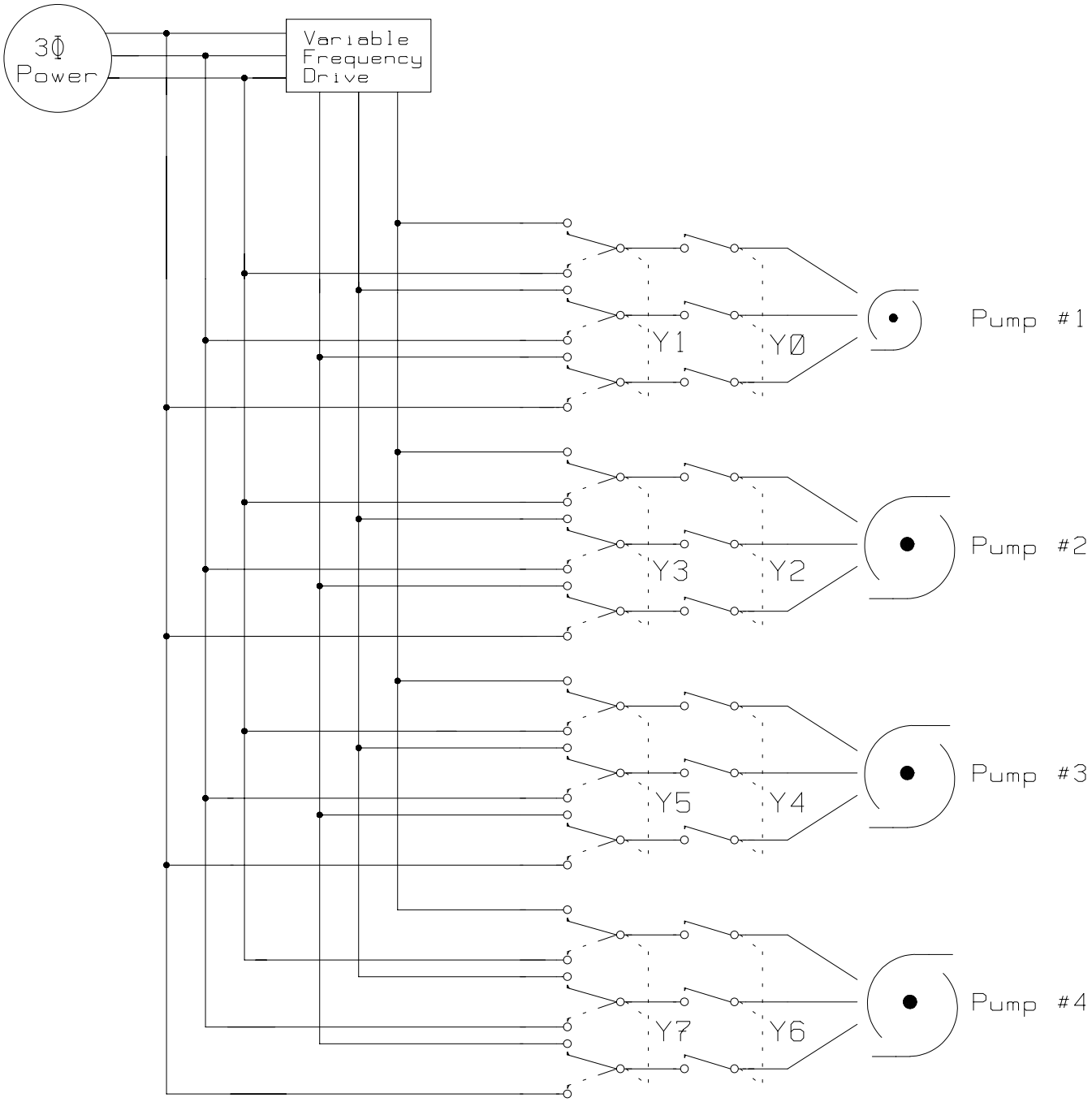


Figure 1. Pressure control pump wiring diagram

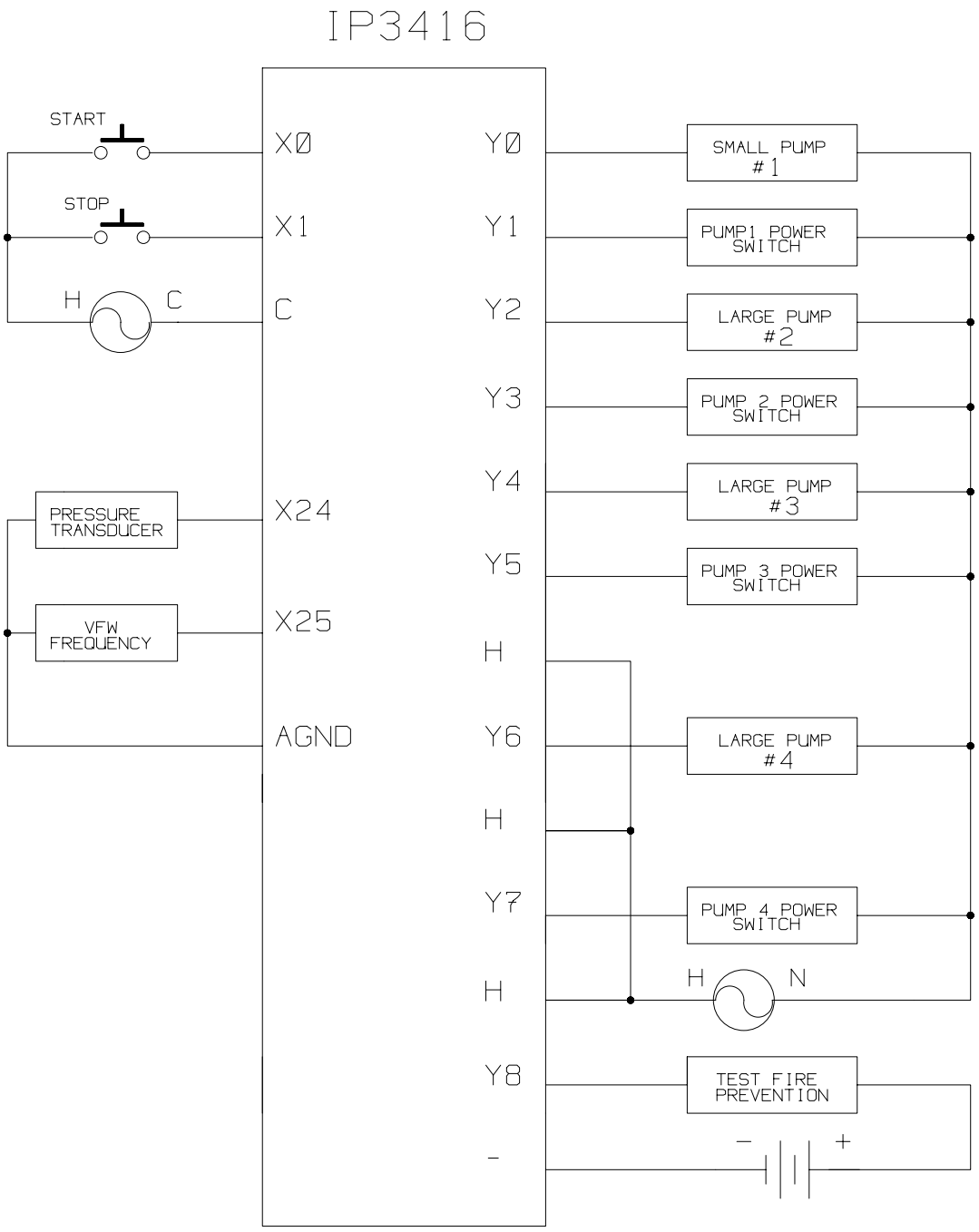


Figure 2. Pressure control hardware diagram

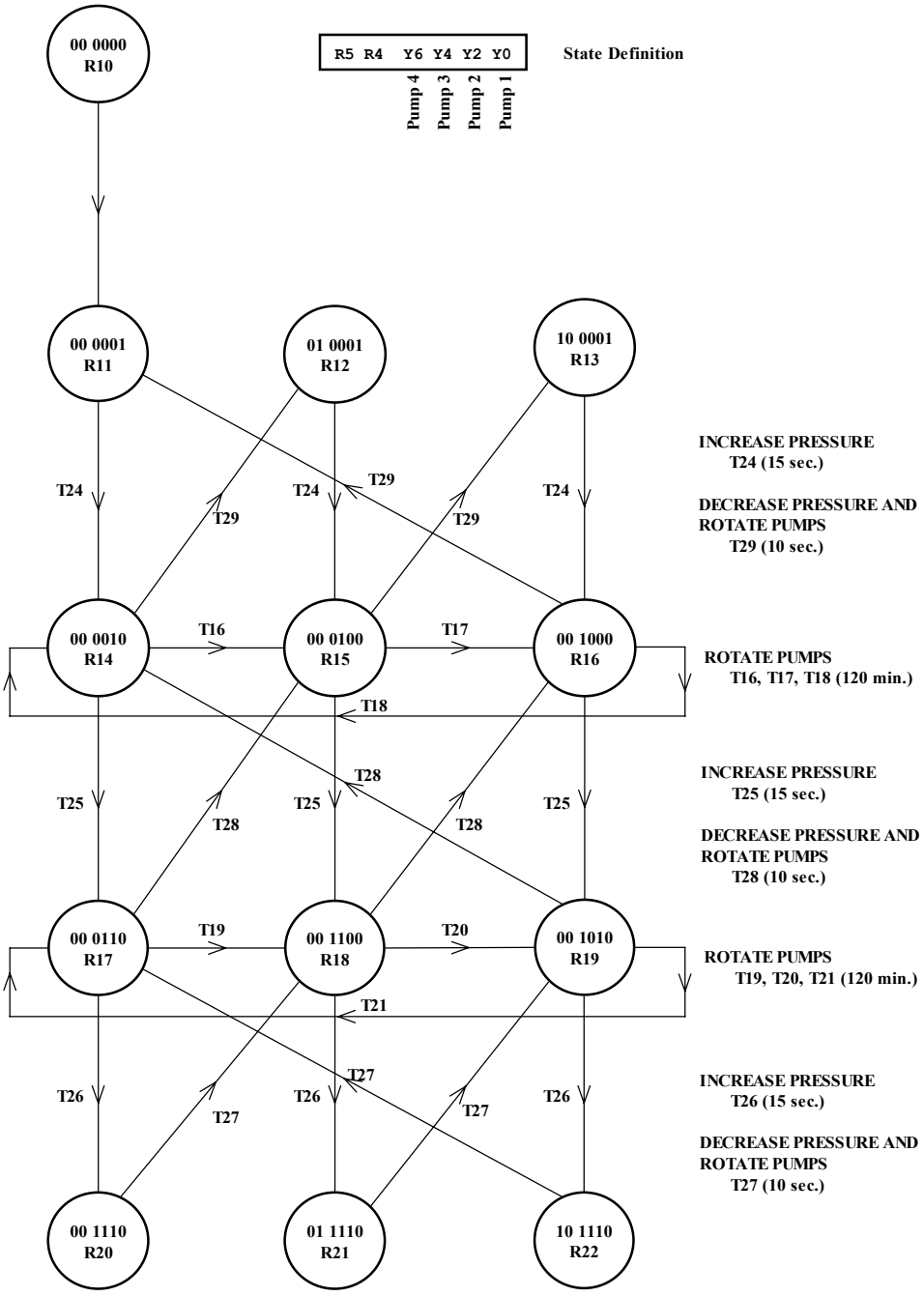
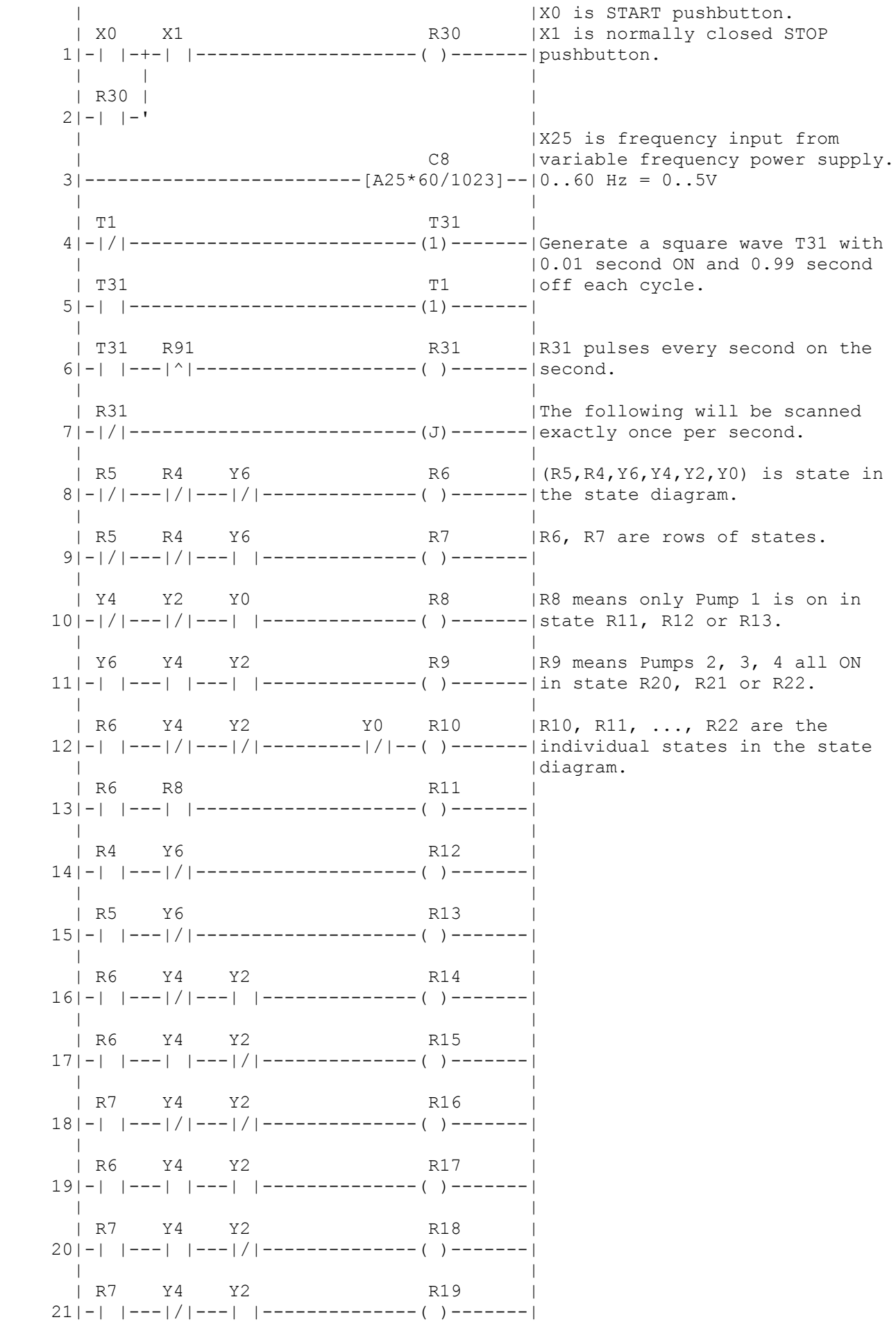


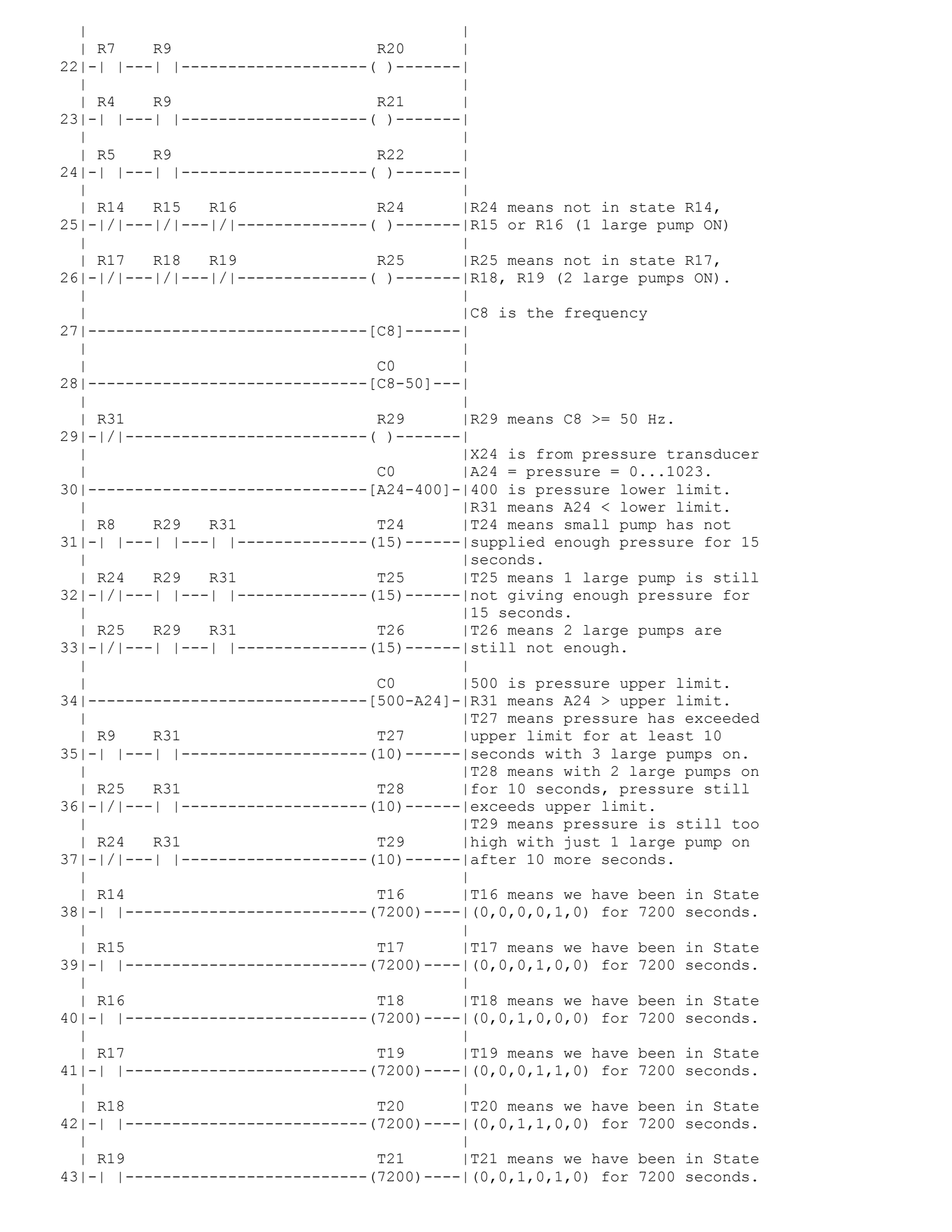
Figure 3. Pressure control state diagram

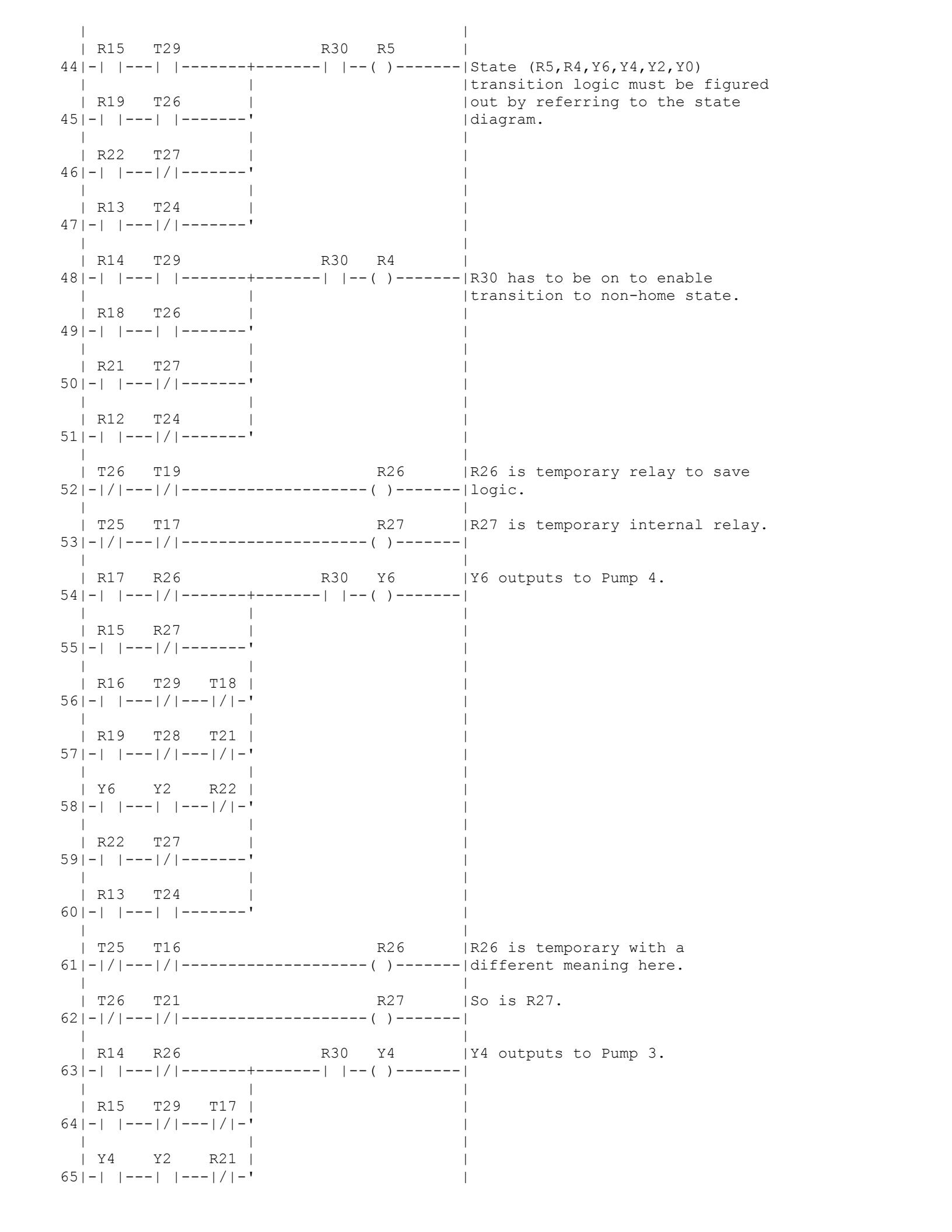
The state diagram depicts the transition between one state (which pumps are on) and another state. Timers control the transitions. I.e. a transition will occur from state R11 to state R14 when timer T24 has timed-out. A breakdown of the timers follows,

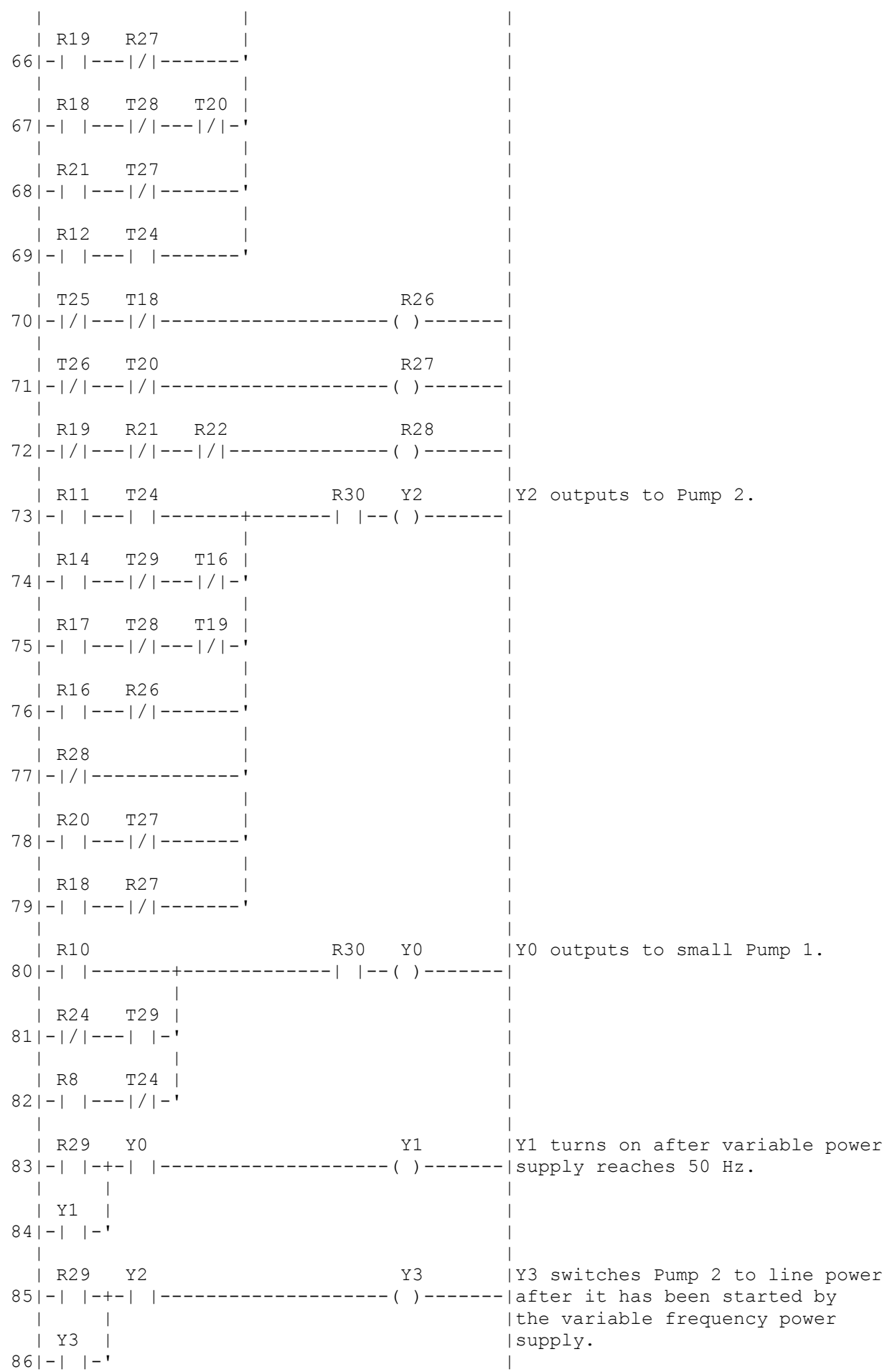
T16, …, T21 Rotate pumps after 2 hours of continuous operation.
T24, …, T26 Increase pressure by turning on another pump after 15 seconds.
T27, …, T29 Decrease pressure by turning off a pump after 10 seconds and at the same time rotate the pumps.

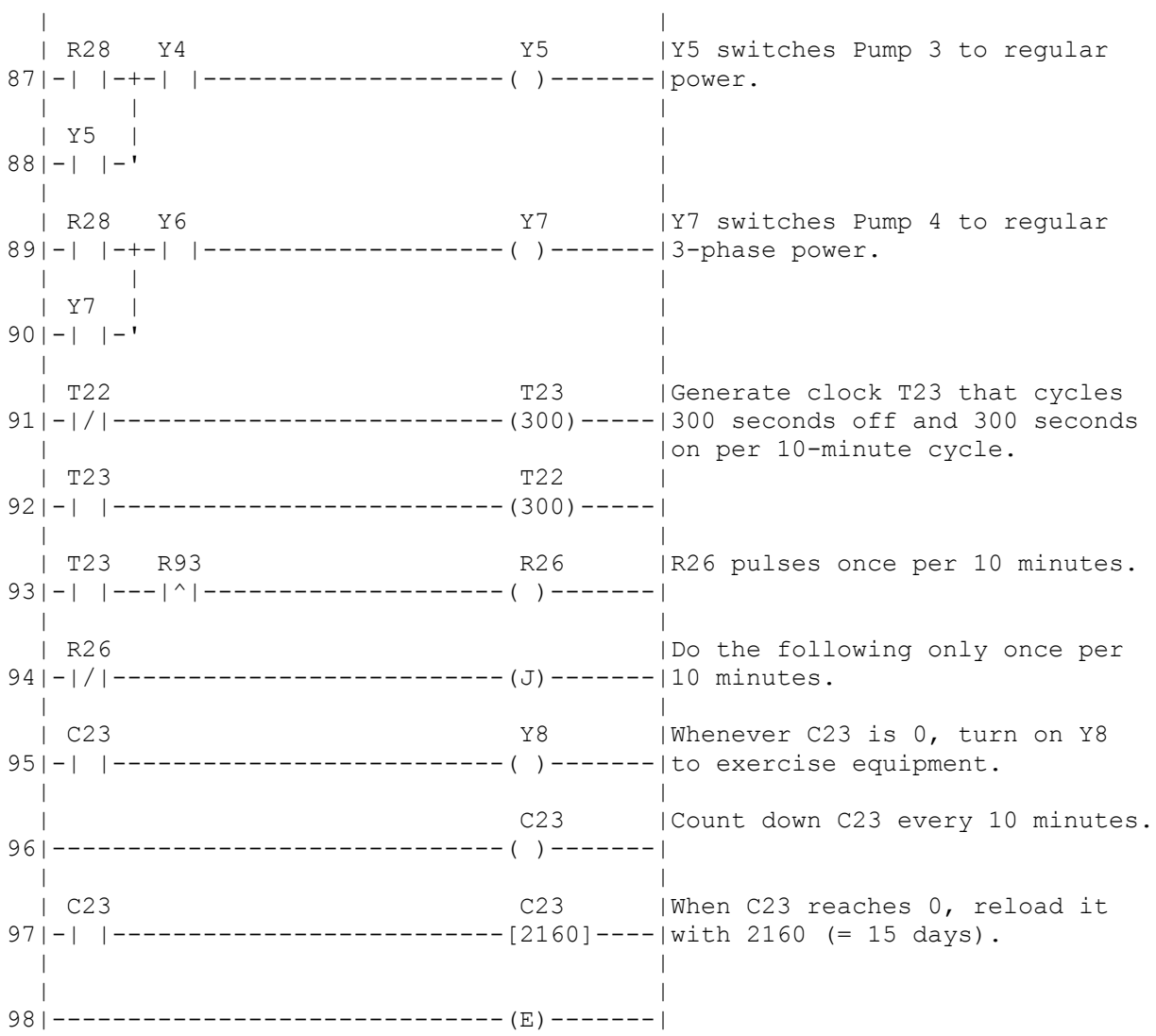
The following is the RLL that performs all the necessary tasks,




R7 R9 R20
R4 R9 R21
R5 R9 R22
R14 R15 R16 R24
R17 R18 R19 R25
[C8]
C0
[C8-50]
R31 R29
C0
[A24-400]
R8 R29 R31 T24 (15)
R24 R29 R31 T25 (15)
R25 R29 R31 T26 (15)
C0
[500-A24]
R9 R31 T27 (10)
R25 R31 T28 (10)
R24 R31 T29 (10)
R14 T16 (7200)
R15 T17 (7200)
R16 T18 (7200)
R17 T19 (7200)
R18 T20 (7200)
R19 T21 (7200)
R24 means not in state R14, R15 or R16 (1 large pump ON)
R25 means not in state R17, R18, R19 (2 large pumps ON).
C8 is the frequency
R29 means C8 >= 50 Hz.
X24 is from pressure transducer
A24 = pressure = 0...1023.
400 is pressure lower limit.
R31 means A24 < lower limit.
T24 means small pump has not supplied enough pressure for 15 seconds.
T25 means 1 large pump is still not giving enough pressure for 15 seconds.
T26 means 2 large pumps are still not enough.
500 is pressure upper limit.
R31 means A24 > upper limit.
T27 means pressure has exceeded upper limit for at least 10 seconds with 3 large pumps on.
T28 means with 2 large pumps on for 10 seconds, pressure still exceeds upper limit.
T29 means pressure is still too high with just 1 large pump on after 10 more seconds.
T16 means we have been in State (0,0,0,0,1,0) for 7200 seconds.
T17 means we have been in State (0,0,0,1,0,0) for 7200 seconds.
T18 means we have been in State (0,0,1,0,0,0) for 7200 seconds.
T19 means we have been in State (0,0,0,1,1,0) for 7200 seconds.
T20 means we have been in State (0,0,1,1,0,0) for 7200 seconds.
T21 means we have been in State (0,0,1,0,1,0) for 7200 seconds.


R15 T29 R30 R5
State (R5,R4,Y6,Y4,Y2,Y0)
transition logic must be figured
out by referring to the state
diagram.
R19 T26
R22 T27
R13 T24
R14 T29 R30 R4
R30 has to be on to enable
transition to non-home state.
R18 T26
R21 T27
R12 T24
T26 T19 R26
R26 is temporary relay to save
logic.
T25 T17 R27
R27 is temporary internal relay.
R17 R26 R30 Y6
Y6 outputs to Pump 4.
R15 R27
R16 T29 T18
R19 T28 T21
Y6 Y2 R22
R22 T27
R13 T24
T25 T16 R26
R26 is temporary with a
different meaning here.
T26 T21 R27
So is R27.
R14 R26 R30 Y4
Y4 outputs to Pump 3.
R15 T29 T17
Y4 Y2 R21


R19 R27
R18 T28 T20
R21 T27
R12 T24
T25 T18 R26
T26 T20 R27
R19 R21 R22 R28
R11 T24 R30 Y2
Y2 outputs to Pump 2.
R14 T29 T16
R17 T28 T19
R16 R26
R28
R20 T27
R18 R27
R10 R30 Y0
Y0 outputs to small Pump 1.
R24 T29
R8 T24
R29 Y0 Y1
Y1 turns on after variable power supply reaches 50 Hz.
Y1
R29 Y2 Y3
Y3 switches Pump 2 to line power after it has been started by the variable frequency power supply.
Y3


R28 Y4 Y5
Y5 switches Pump 3 to regular power.
Y5
R28 Y6 Y7
Y7 switches Pump 4 to regular 3-phase power.
Y7
T22 T23 (300)
Generate clock T23 that cycles 300 seconds off and 300 seconds on per 10-minute cycle.
T23 T22 (300)
T23 R93 R26
R26 pulses once per 10 minutes.
R26 (J)
Do the following only once per 10 minutes.
C23 Y8
Whenever C23 is 0, turn on Y8 to exercise equipment.
C23
Count down C23 every 10 minutes.
C23 C23 [2160]
When C23 reaches 0, reload it with 2160 (= 15 days).
(E)